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An unexpected record of *Simothraulopsis* Demoulin, 1966 (Ephemeroptera, Leptophlebiidae) in the Paraná Basin, Brazil

Luiz R. R. Faria[1], Frederico F. Salles[2]

1 Instituto Latino-Americano de Ciências da Vida e da Natureza, Universidade Federal da Integração Latino-Americana, Av. Tarquínio Joslin dos Santos, 1000, Jd. Universitário, 85.870-901, Foz do Iguaçu, PR, Brazil. **2** Museu de Entomologia, Departamento de Entomologia, Universidade Federal de Viçosa, Av. P. H. Rolfs, s/n, Campus Universitário, 36.570-900, Viçosa, MG, Brazil.
Corresponding author: Frederico Falcão Salles, ffsalles@gmail.com

Abstract
We recorded for the first time the occurrence of the mayfly genus *Simothraulopsis* Demoulin, 1966 in the Paraná Basin. Adults of *Simothraulopsis demerara* (Traver, 1947) and *Simothraulopsis diamantinensis* Mariano, 2010 were collected using a white sheet light trap installed on the bank of Iguaçu River, near the falls in Iguaçu National Park, Brazil. These new records significantly expand southwards the distribution of the genus.

Key words
Atalophlebiinae, biogeography, distribution, *Homothraulus*, Iguaçu National Park, mayfly, Parque Nacional do Iguaçu.

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Introduction

Knowledge concerning the systematics and distribution of the genus *Simothraulopsis* Demoulin, 1966 (Ephemeroptera, Leptophlebiidae) has increased considerably in the last few years with the description of several new species (Kluge 2007, Mariano 2010, Nascimento et al. 2017, Lima 2018) and a generic revision (Nascimento et al. 2017). From 1966, when the genus was described, to 2007, the distribution of *Simothraulopsis* was known to be restricted to a few localities in northern South America. Kluge (2007) described 2 new species from the Peruvian Amazon, Mariano (2010) and Lima (2018) described 2 new species each from northeastern Brazil, and Nascimento et al. (2017) described 4 new species mainly from northern and southeastern Brazil and provided several new records within the country.

The genus currently comprises 11 species, and its distribution ranges from the limits of Rio de Janeiro and Espírito Santo (ca 020.5° S) to northern Venezuela (ca 07.5° S), and from the coasts of Alagoas and Pernambuco (ca 035.3° W) to the Peruvian Amazon (ca 073.4° W).

In general, the species of this genus present restricted distributions. A group of species may be considered as Amazonian species (*Simothraulopsis dominguezi* Nascimento, Salles & Hamada, 2017; *Simothraulopsis inaequalis* Nascimento, Salles & Hamada, 2017; *Simothraulopsis plesius* Kluge, 2007; *Simothraulopsis sabalo* Kluge, 2007), while another group comprises Atlantic Forest/Cerrado species (*Simothraulopsis caliginosus* Nascimento, Salles & Hamada, 2017; *Simothraulopsis diamantinensis* Mariano, 2010; *Simothraulopsis eurybasis* Nascimento, Salles & Hamada, 2017; *Simothraulopsis gracilianus* Lima, 2018; *Simothraulopsis sinuosus* Lima, 2018). Only two species, *Simothraulopsis demerara*

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(Traver, 1947) and *Simothraulopsis janae* Mariano, 2010, are found both in Amazonia, Central Brazil, and the Atlantic Forest. For *S. demerara*, its distribution even reaches northern Venezuela (Nascimento et al. 2017).

According to Savage (1987) and Dominguez et al. (1997), and recently corroborated by Nascimento et al. (2017) and Salles and Boldrini (2019), *Simothraulopsis* is closely related to *Homothraulus* Demoulin, 1955. While the first genus is widely distributed, as mentioned above, *Homothraulus* is known from only a few localities in the Paraná Basin. It is noteworthy that, until now, the distributions of these genera were not known to overlap.

Based on adults collected at the Iguaçu National Park, we present the first report of *S. demerara* and *S. diamantinensis* from the Paraná Basin. These new records significantly expand southwards the known distribution of the genus.

Methods

Fieldwork was carried out in the Iguaçu River, just upstream the Iguaçu Falls, Iguaçu National Park, Brazil, in 2018. Mayfly subimagos and adults were captured with white sheet light traps from 18:00 to 22:00 h. Collected specimens were fixed in 80% ethanol. The identification of *Simothraulopsis* specimens were based on Mariano (2010) and Nascimento et al. (2017). Collections were made under a license issued by Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) to LRRF (#53938). All the material is deposited in the Entomological Collection of Universidade Federal da Integração Latino-Americana (UNILA).

Previous records for the species were compiled from the following studies: (i) *S. diamantinensis*; Mariano 2010, Campos et al. 2017, Nascimento et al. 2017 and Costa et al. 2018; (ii) *S. demerara*; Traver 1947, Demoulin 1966, Hubbard 1982, Domínguez et al. 1997, Salles et al. 2010, Lima et al. 2015, Campos et al. 2016, Lima et al. 2016, Takiya et al. 2016, Boldrini and Krolow 2017, Nascimento et al. 2017, and Costa et al. 2018. When the geographic coordinates of a given record were not made available by these authors, we used the coordinates of the municipality where the record was taken. These coordinates were obtained in an online global gazetteer (http://www.fallingrain.com/world/index.html) and the shapefile of Ottobasins presented in the distribution map was obtained in the database of ANA, the National Water Agency of Brazil (http://dadosabertos.ana.gov.br). The distribution map (Fig. 1) was made using DIVA-GIS, v. 7.5 (Hijmans et al. 2012).

Results

New records. Brazil: Paraná: Foz do Iguaçu: Parque Nacional do Iguaçu (Iguaçu River, just upstream Iguaçu Falls; 025.6927° S, 054.4331° W), collected by F.F. Salles & M. Fianco, November 24th, 2018. *Simothraulopsis demerara* (Figs 1A, 2A): 2 males (UNILA EP001, EP002); *S. diamantinensis* (Figs 1B, 2B): 7 males (UNILA EP003, EP004, EP005, EP006, EP007, EP008, EP009).

Identification. Specimens were determined using a combination of characters (for terminology of telopenis, see Kluge 2007, Salles and Boldrini 2019).

Simothraulopsis demerara: telopenis narrow (penis lobe with spine-like projection, as illustrated in Nascimento et al. 2017); inner margins of penis lobes divergent; telopenis anteriorly directed; penis lobes fused on basal third; and hind wing almost completely black.

Simothraulopsis diamantinensis: telopenis narrow; inner margins of penis lobes divergent; telopenis mesally directed; and MP fork asymmetric.

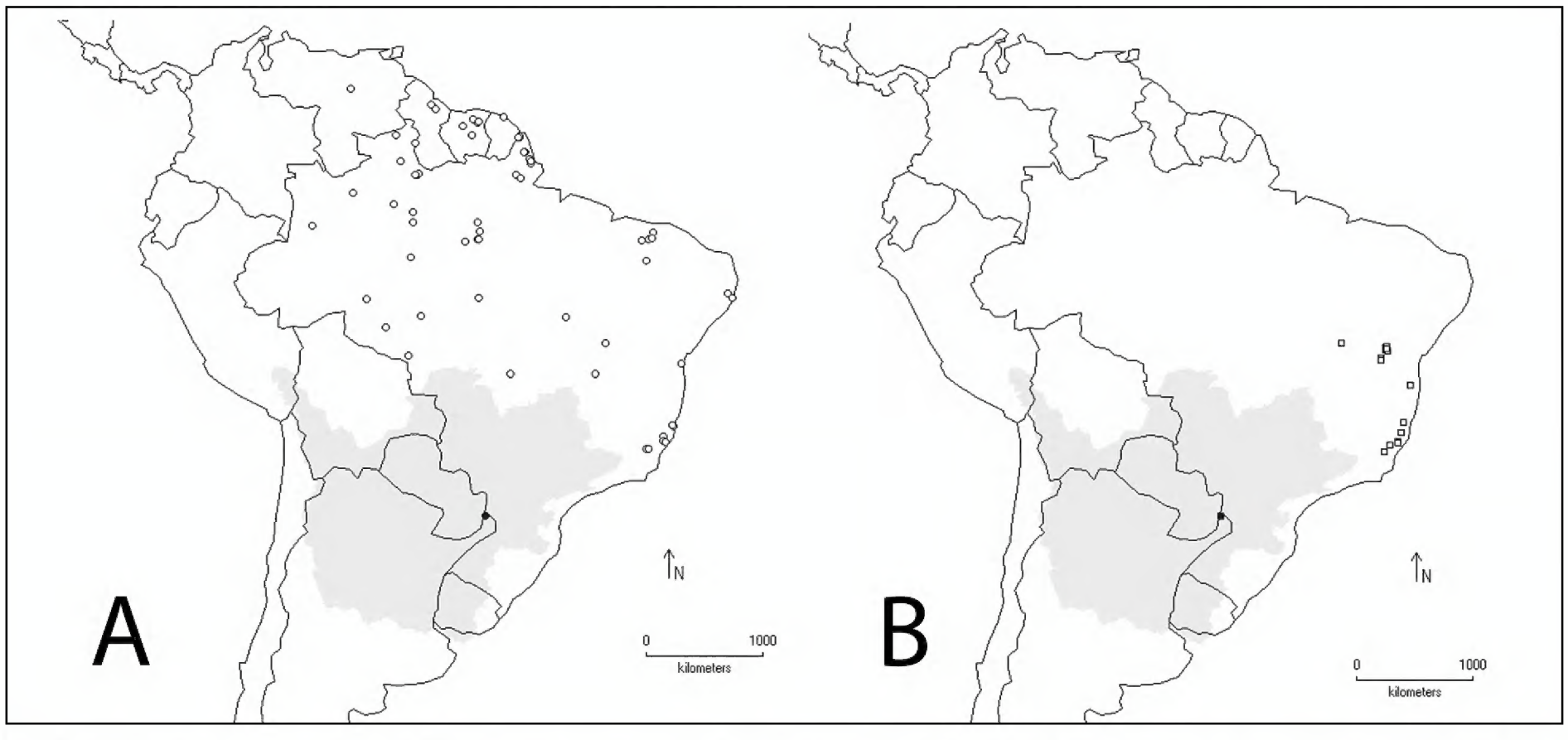

Figure 1. Distribution map of *Simothraulopsis demerara* and *S. diamantinensis*. **A.** *S. demerara*: previous records (open circles) and the new record at Iguaçu National Park (solid circle). **B.** *S. diamantinensis*: previous records (open squares) and the new record at Iguaçu National Park (solid square). The Prata/Paraná/Paraguai Ottobasin (see Methods) is presented in gray.

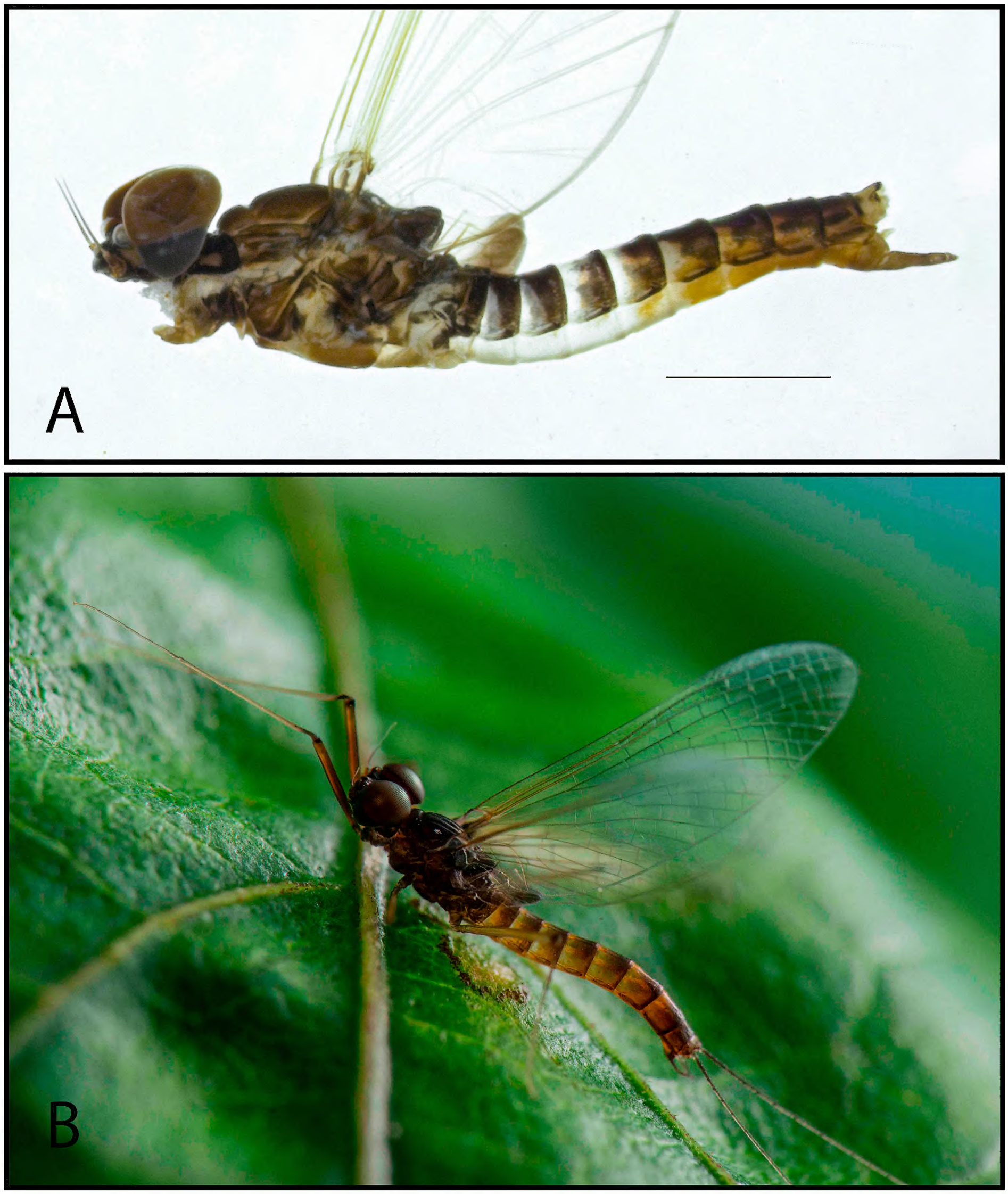

Figure 2. *Simothraulopsis demerara* and *S. diamantinensis* from the Paraná Basin. **A.** *S. demerara*, habitus. **B.** *S. diamantinensis*.

Discussion

The new records of *S. demerara* and *S. diamantinensis* represent a major expansion of the distribution of the genus to the south (ca 020.5° S to ca 025.7° S). These records represent an expansion of ca 600 km from the southernmost previously known record of the genus in southern Espírito Santo state.

The new records become even more important in the context of the Paraná Basin. Among the *Homothraulus* lineage (see Salles and Boldrini 2019), *Simothraulopsis* appears as the sister group of *Homothraulus* (see also Domínguez 1999), a genus known from a few localities within the Paraná Basin. With the new records, all the 3 genera of the *Homothraulus* lineage (i.e. *Farrodes* Peters, 1971, *Homothraulus*, and *Simothraulopsis*) are now known to occur in the basin. In *Farrodes*, 1 species, *Farrodes iguazuanus* Domínguez & Savage, 1987, also occurs in the Iguaçu River (Domínguez and Savage 1987).

Some intraspecific variation of both color pattern and structural differences in forewings and penis lobes are thought to occur among populations of *S. demerara*

(Nascimento et al. 2017). However, Nascimento et al. stated that there is the possibility of sibling species within what we nowadays call *S. demerara*. One of their arguments in support of this possibility is the wide distribution of this species. Our findings reinforce the need for a phylogeographic study of *S. demerara*.

Finally, in the distribution map of *S. demerara* presented by Nascimento et al. (2017: fig. 49), they present a record of *S. demerara* near the border of Mato Grosso and Mato Grosso do Sul states, which might represent a previous occurrence in the Paraná Basin of this species. However, this record was not included in the section "material examined", which raises doubt about the information. After contacting the senior author of the paper, Dr Jeane M.C. do Nascimento (Instituto Nacional de Pesquisas da Amazônia), she was unable to locate specimens from this locality or the source for such a record. We consider, therefore, that the previous distribution of the species and genus at the Paraná Basin was a mistake.

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Authors' Contributions

LRRF processed collected material; FFS carried out fieldwork and identified the specimens; both authors made the plates, the distribution maps and wrote the manuscript.

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